INTRODUCTION

This manual provides technical assistance in the development and implementation of sound scientific monitoring of coastal restoration efforts. It supports the maximization of societal and environmental benefits of coastal habitats throughout the estuaries and freshwater coastal ecosystems of the United States and its protectorates.

The document is not a restoration manual, nor does it develop specific monitoring plans. Instead, it outlines the steps necessary in the development of a scientifically sound and fiscally responsible restoration monitoring plan and provides tools to assist monitoring plan development and guide decision-making. This document provides practitioners with a scientifically sound and statistically valid basis and framework through which monitoring plans can be developed.

There are two volumes of this manual. In this first volume (*A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000*), readers will find a framework for the creation of a restoration monitoring program. The framework explains where monitoring fits into the restoration process, how to create a monitoring plan, and important information that should be considered when monitoring specific habitats.

The second volume (*Tools for Monitoring Coastal Habitats*) contains detailed discussions of the habitats including techniques manuals and quality control/quality assurance documents for monitoring in each habitat. Volume Two also includes an inventory of coastal restoration monitoring programs (including those in the Great Lakes region), an overview of Federal legislation associated with restoration monitoring, a cost analysis of monitoring expenses, and a discussion of socioeconomic issues associated with coastal habitat restoration. It will also provide readers with abundant references and contacts that can be pursued for further information on preparing a monitoring program.

The Audience – This manual is written for those involved in developing and implementing restoration monitoring plans, both scientists and non-scientists. This includes restoration professionals in academia and private industry, as well as those in Federal, state, local, and tribal governments. Volunteer groups, non-governmental organizations, environmental advocates, and individuals participating in restoration monitoring planning will also find this information valuable.

Why This Manual Was Written – The Estuary Restoration Act (ERA), Title I of the Estuaries and Clean Waters Act of 2000, was created to promote the restoration of coastal and estuarine habitats. Under the act, the National Oceanic and Atmospheric Administration (NOAA) is tasked with providing guidance for the development and implementation of monitoring for projects funded under the Act.

Within the tens of thousands of kilometers of United States coastline included under the ERA are diverse habitats, ranging from tropical coral reefs to temperate freshwater marshland to Arctic rocky shores. Even with the diversity of habitats that may need restoration and the extreme geographic range across which these habitats occur, there are consistent principles and approaches that form a common basis for effective restoration monitoring.

Figure 1. Red mangrove located along John Pennekamp State Park, Florida. Photo courtesy of Richard B. Mieremet, NOAA Office of Sustainable Development and Intergovernmental Affairs. Publication of the NOAA Central Library. http://www.photolib.noaa.gov/coastline/line0013.htm

Without effective restoration monitoring, projects have several risks. It may be impossible to obtain early warnings indicating that a restoration project is not on track. The lack of monitoring makes it difficult to gauge how well a restoration site is functioning ecologically both before and after completion. In addition, the lack of monitoring may lead to poor project coordination. If multiple projects in the same watershed or ecosystem are not evaluated using a complementary set of protocols, a disjointed effort may produce a patchwork of restoration sites with varying degrees of success (Galatowitsch et al. 1998) and little means of comparing results or approaches among projects.

What This Manual Is – This manual is designed to outline the steps necessary to develop a scientifically sound and fiscally responsible restoration monitoring plan and to help identify the characteristics that restoration practitioners consider valuable indicators of a functioning habitat. It is not a restoration monitoring "cookbook" that provides templates of monitoring plans for specific habitats. The interdependence of a large number of site-specific factors does not allow a rigid approach in designing monitoring guidance with wide applicability (Kusler and Kentula 1990). Although consistent approaches and principles can be identified, specific monitoring methods will vary according to the goals of the project.

Why This Approach- Habitat types vary in physical structure and function within and between regions. Monitoring techniques used should be tailored to these differences. Even within a single habitat type, there are regional and geographic differences that make recommendation of one technique a useless exercise. For example, in the southeastern United States where tidal amplitude is moderate, an appropriate technique for assessing fish and invertebrate abundance in a restored

salt marsh is the use of a block net, fyke net, Breeder trap, or pit trap. However, in the Gulf of Mexico where marshes may remain flooded for long periods, none of these techniques may be appropriate. A drop sampler or pop net may be better. On the west coast where marsh systems tend to be small monoculture stands, it is often necessary to block the entire tidal inlet to assess faunal components. In other areas, beach seines are used. There are over a dozen techniques to measure fish and invertebrate presence, absence, or abundance. The scientific community varies greatly in the technique and monitoring design preferred.

Some historical databases and ongoing programs have well established sampling protocols that have been used for extended periods. Resource managers and scientists are often unwilling to change techniques for a restoration project because it would result in a decreased ability to compare data across the watershed and over time. Programs with strong investments in sampling protocols include the Southern California Coastal Water Research Project, Gulf of Maine Council Gulf Watch Program, Chesapeake Bay Monitoring Program, San Francisco Bay Conservation and Development Commission, Gulf of Alaska Ecosystem Monitoring and Research (GEM) program, Public Service Enterprise Group (PSEG) Estuary Enhancement Program, CALFED Bay Delta Program, and the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). Techniques for evaluating a specific habitat characteristic vary among these programs and can even vary within a single program to accommodate local conditions. These programs address technical soundness in restoration monitoring protocols through a scientific advisory group that thoroughly reviews restoration monitoring plans.

The selection of sampling designs and statistical protocols are also influenced by local conditions. For example, the length of the growing season varies tremendously along the coastal United States. Restoration projects involving planting vegetation in the southeastern or Gulf regions are monitored on very different time schedules than projects constructed in higher latitudes. Additionally, statistical sampling designs will vary according to the structure of the habitats (e.g., stratified random sampling, line transects, and time series analysis). Landscape considerations such as patchiness and degree of channelization play a part in what sampling and statistical analysis techniques are used. One cannot dictate the timing of sampling or the way in which the data are analyzed without understanding the local conditions that comes through field evaluation.

Finally, a variety of available techniques exist for almost all metrics or characteristics recommended for evaluation. There is no one technique that fits all; each situation needs to be evaluated individually using the same approach in the restored as in the reference sites. It would be presumptive to recommend a single technique for a specific characteristic when scientists frequently do not agree among themselves on the most appropriate method to be used.

References

Galatowitsch, S.M., A.G. van der Valk, and R.A. Budelsky. 1998. Decision-making for prairie wetland restorations. *Great Plains Research* 8: 137-155.

Kusler, J. A. and M. E. Kentula. 1990. Executive summary, pp. xvii-xxv. In J. A. Kusler and M. E. Kentula (eds.), Wetland Creation and Restoration: the Status of the Science. Island Press, Washington, D.C.